INTERNATIONAL PERSPECTIVE ON COATED CONDUCTORS

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Information Sources

- 10th International Workshop on Critical Currents, Göttingen, Germany, June 2001.
- International Cryogenic Materials Conf., Madison, July 2001.
- European Conf. on Appl. Superconductivity, Copenhagen, Denmark, Aug. 2001.
- International Sym. on Superconductivity, Kobe, Japan, Sept. 2001.
- Materials Research Soc. Fall 2001 Meeting, Boston, Nov. 2001.
- Superconductor Week, 2001.
- Grant (EPRI), Suenaga (NBL), Shiohara (ISTEC), Izumi (ISTEC), Park (KERI, Korea).

Japanese Organizations Supporting Superconductor R&D

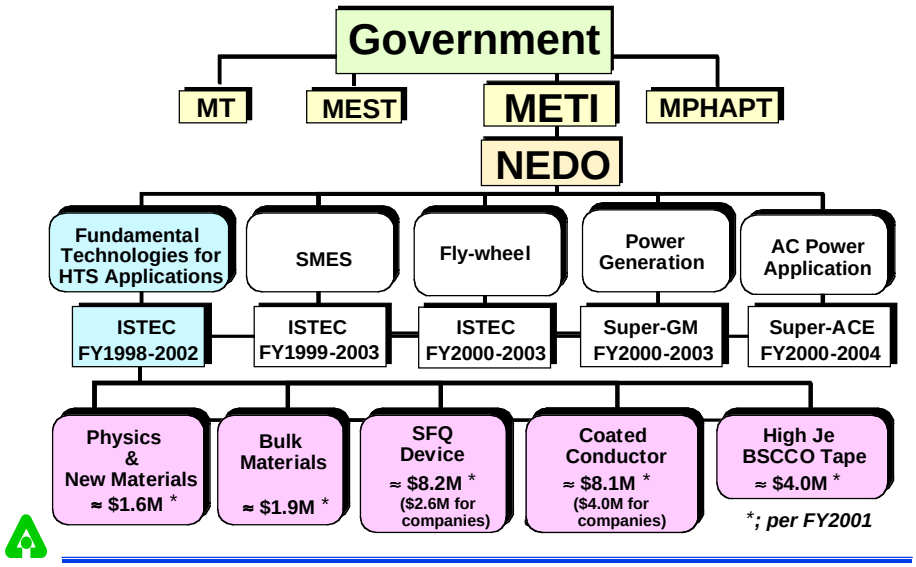
- METI - Ministry of Economy, Trade, and Industry
- NEDO - New Energy and Industrial Technology Development Organization
- MEST - Ministry of Education, Culture, Sports, Science and Technology
- MT - Ministry of Land, Infrastructure and Transport
- MPHAPT - Ministry of Public Management, Home Affairs, Post and Telecommunications

FY2001 (April '01 - March '02) Budget for Superconductivity-related R&D in Four Ministries

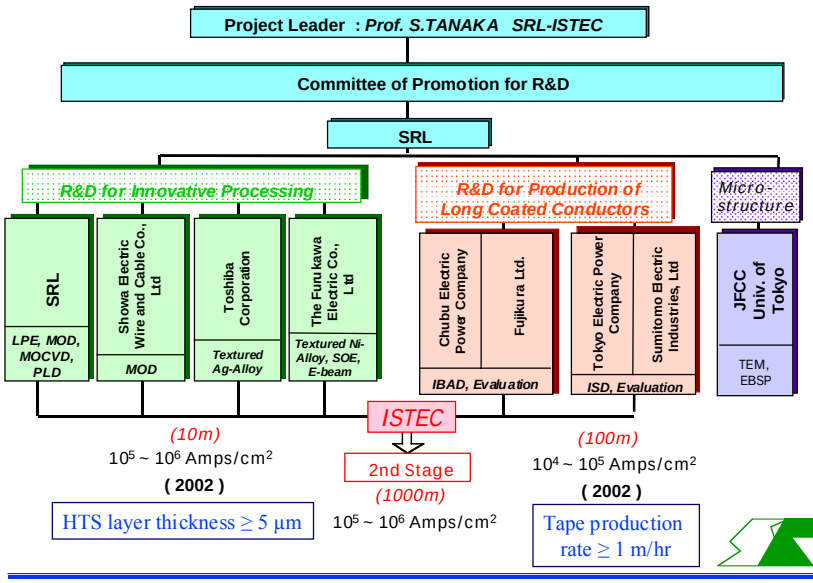
(Unit: million yen)

Name of Ministry	Themes	FY2000 Budget	FY2001 Requested Budget
METI	R&D on superconducting generators, flywheel, AC power application, and R&D on fundamental technologies for superconducting applications	8,025	9,093
MEST	Multi-core project for superconducting material studies, nuclear fusion, etc. Consolidation of superconductivity-related research and educational systems	3,275	3,261
MT	MAGLEV	1,184	1,380
MPHAPT	Research on ultrahigh frequency and high-speed circuit technology using superconducting devices	111	Budget within 19,184
	Total	**12,594**	**13,733**

Superconductivity Projects in JAPAN



Organization for Development of CC

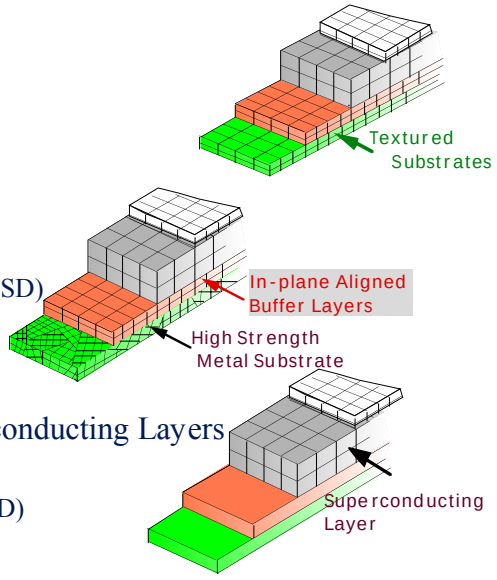


ISTEC/SRL Funding Situation
(Japanese Fiscal Year April 1- March 31)

- FY 2002 (starts April '02) is expected to get ≈ 10% increase.
- Fundamental Technologies for HTS Applications program will have 2.7 Billion Yen (≈ $25 M).
- Current 5-yr program ends at the end of JFY '02 (March '03).
- ISTEC will propose to METI an extension to another 5-yr term.
  - will have an intermediate set of goals to fill in the first two years.

Approach

- Process for Textured Metallic Substrate
  - RABiTS™
  - SOE, Cute
- Process for In-Plane Aligned Buffer Layers
  - Inclined Substrate Deposition (ISD)
  - Ion Beam Assisted Deposition (IBAD)
- Innovative Process for Superconducting Layers
  - Liquid Phase Epitaxy (LPE)
  - Metal Organic Deposition (MOD)

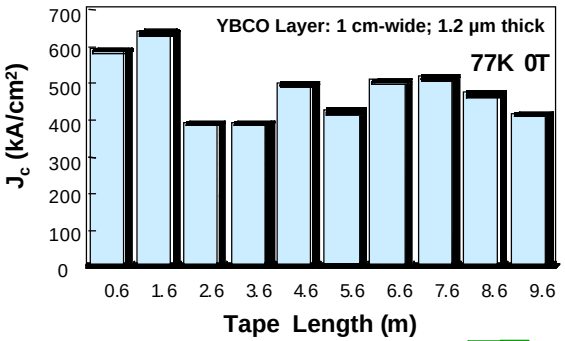


Major Results – Japan

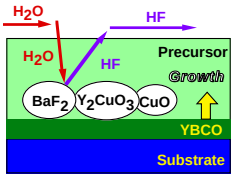
- Textured Metallic Substrates
  - $J_c = 3 \times 10^5$ A/cm^2 on SOE (short sample)
  - $J_c > 10^5$ A/cm^2 on 5-m Ag-Cu/Ag-Ni clad-type tape
- ISD
  - Produced 50-m long textured YSZ with CeO_2 cap-layer (ISD speed: 1.0 m/h)
  - $J_c = 10^5$ A/cm^2 on 10-m long tape (PLD speed: 1.2 m/h)
- IBAD
  - 60-m long IBAD/$Gd_2Zr_2O_7$ tape (IBAD speed: 1 m/h; in-plane FWHM = 16-18°)
  - $I_c = 50$ A ($J_c = 0.42$ MA/cm^2) on 9.6-m long 1-cm wide, 1.2 µm thick tape (PLD speed: 1 m/h; in-plane FWHM = 9°)
  - $I_c = 150$A ($J_c = 1.2$ MA/cm^2) on 8-cm long tape.

Major Results

Measuring Length ; 9.6m
YBCO Thickness ; 1.2 µm
I_c (77K, 0T) ; 50A
J_c (77K, 0T) ; 4.2x10^5 A/cm^2



Innovative Process for Superconducting Layer (MOD)



- Major Results

① Technology for High Quality Film Deposition;

J_c≈11 MA/cm² on 50-mm dia. film.

Achieved High J_c in Combination of IBAD & TFA-MOD
J_c = 2.5 MA/cm² (0T), 0.17 MA/cm² (5T) @77 K

② Process for Thick Film Deposition;

acetylacetonate process

Improved I_c & J_c by means of Triple Coating (0.9 - 1μm) in TFA-MOD

on Single Crystal Sub. I_c*=280 A/cm-width, J_c= 3.1 MA/cm²

on Metal Sub. (IBAD) I_c*=153 A/cm-width, J_c=1.6 MA/cm²

③ Technology for Long Length Production

- Deposition of 10 cm long tape by dip-coating & beed-coating

Current Status & Future Prospect

Present Status (FY2001)	Goal of This Project (FY2002)	Future Targets for Real Industrial Application
<Long Length Production> 1.Length : ≒10m 2. Jc (77K, 0T): $>10^5$A/cm² 3. . Production Rate: 1m/h <Innovative Processing> 1.Length : ≒10cm 2.Jc : Jc (77K, 0T) ≒2.5x10^6A/cm² Jc (77K, 5T) ≒1.7x10^5A/cm²	<Long Length Production> 1. Length : >50m 2. Jc (77K, 0T): $>10^4$A/cm² 3. Production Rate: 1m/h 4.SC Thickness : ≒100μm <Innovative Processing> 1.Length : >1m 2. Jc : Jc (77K, 0T) ≒10^6A/cm² (L=20cm) Jc (77K, 5T) ≒3x10^5A/cm² (L=20cm)	<Tape for Low Field Application> 1. Length : ≒1,000m 2. Ic (77K, 0T) : >40A Jc (77K, 0T) =1x 10^6A/cm² 3. Production Rate: >60m/h 4. Sub.Width/Thickness : ≒50μm /≒4mm 5.Cost : <$30-50/kA・m <Tape for High Field Application> 1 Length : ≒500m 2. Ic (64K, 5T): >40A Jc (64K, 5T) =10^5A/cm² 3. Production Rate: >20m/h 4. Sub.Width/Thickness : ≒50μm /≒10mm 5.Cost : <$30-50/kA・m

$146 Million Korean Superconductivity Initiative
(Government: $100M; Industry: $46M; 2001-2010)

Organization

Minister of Korean Ministry of Science and Technology

Steering Committee | *Director* of CAST | Technical Advisory Committee

DAPAS research group
- Power devices group
- Digital devices group
- Common technology

Administration Office
- Administrative manager
- Technical manager
- . . . . . .

Shared Research Facility

- 15 Industries
- 23 Universities
- 15 Research labs
- 4 Foreign institution

⇒ More international participants wanted

DAPAS — Dream of Advanced Power system by Applied Supercon. Technol.

CAST

Projects of DAPAS

Main category	Projects	Institution
Superconductivity Power devices	• Underground cable	KERI
	• Transformer	Korea Polytechnic Univ.
	• Fault-current limiter	Yonsei Univ./ KEPRI
	• Motor	KERI
Superconductivity Digital devices	• ALU (Arithmetic Logic Unit)	KOPTI
Superconductivity Common technology	• HTS PIT wire	KERI / KIMM
	• HTS CC wire (PVD / MOCVD)	KERI / KAERI
	• Cryogenic technologies	Neuros
	• Electric insulation technologies	Gyeongsang Univ.
	• Fundamental technology of HTS coil	KBSI
	• (joint, AC loss, etc.)	
	• Power system application technologies	KERI

CAST

Korean Institutes

- KERI Korea Electrotechnology Research Institute
- KOPTI Korea Photonic Technology Institute
- KIMM Korea Institute of Machinery and Materials
- KAERI Korea Atomic Research Institute
- KBSI Korea Basic Science Institute

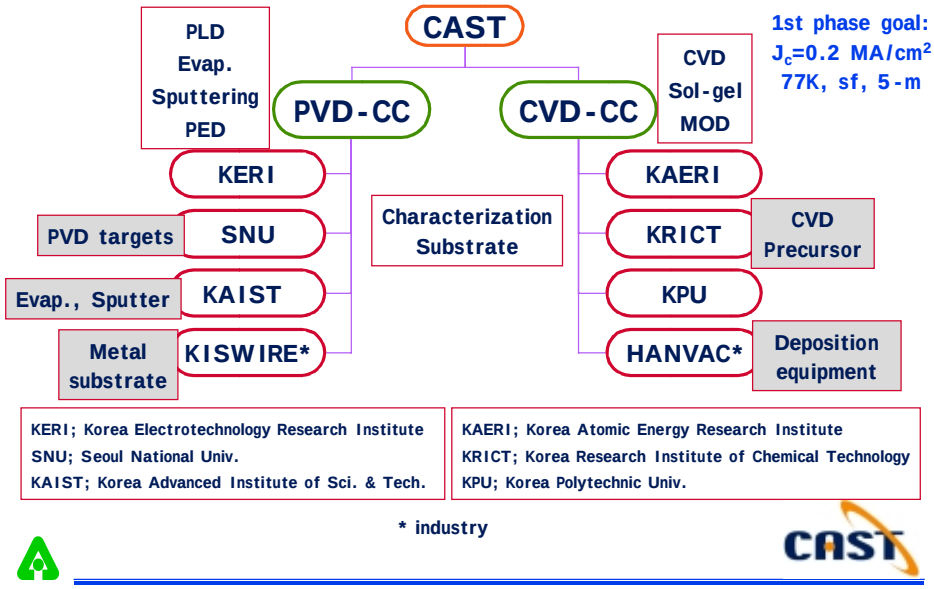
Development Targets of Each Phase

1st Phase	2nd Phase	3rd Phase
2001 2002 2003	2004 2005 2006	2007 2008 2009 2010
Develop HTS wire and system technology suitable for use in electric devices	Develop and test prototypes of electric devices	Develop and test commercial-scale electric devices

Devices: Transmission cable
Transformer
Fault-current limiter
Motor
Arithmetic logic unit

CAST

Coated Conductor Program in CAST



EUROPEAN FRAMEWORK PROGRAM PARTICIPANTS

- U. Göttingen & ZFW
- IFW - Dresden
- TU - München
- Forschungszentrum - Julich
- Siemens
- THEVA GmbH
- Inst. Tech. Phy. - Karlsruhe
- Europa Metalli SpA
- IRC - Cambridge
- Imperial College
- U. Birmingham
- Oxford Instruments
- Atomic Institute - Vienna
- U. Geneva
- MASPEC- Parma
- Alcatel

Results of the European Program

- IBAD @ Göttingen
  - 17.5-m-long IBAD tape (in-plane FWHM = 11-13°; Dep. time: 14 hr)
  - 2-m-long tape with I_c = 142 A (J_c = 1.23 MA/cm^2; 10-mm wide; 1.23 µm thick YBCO)
  - YBCO deposition rate using HR-PLD is 40 nm • m^2/hr
  - Current processing time to make 100-m-long, 3.5-mm-wide YBCO tape is ≈280 hr
  - Total processing time will be reduced to ≈40 hr in ≈2 yrs.
- ISD @ Munich
  - 35-m-long textured MgO (tape speed: 8 m/hr; 200-500 nm/min; 2 µm thick)
  - J_c = 0.8 MA/cm^2 (1.5 cm x 0.5 cm); 0.5 MA (10-cm x 0.8 cm); 0.1 MA (1-m x 0.8 cm).

Results of the European Program (cont.)

- Textured Ni-alloy tapes @ Dresden, Karlsruhe, Europa Metalli, THEVA, Munich, Cambridge
  - Controlled micro-alloying (0.1% Mo) prevents secondary recrystallization
  - High alloy concentration (13% Cr, 9% V) reduce grain boundary grooving but texture is imperfect
  - I_c = 60 A in 9-mm wide, 12-cm long and 1.4 µm thick YBCO ($J_c \approx 0.5 \times 10^6$ A/cm^2)
- Textured Ag-alloy tapes @ Geneva, Oxford
  - $J_c \approx 10^5$ A/cm^2 in short samples
- YBCO deposition
  - PLD, magnetron sputtering, LPE, MOCVD, thermal coevaporation, aerosol.

2001 Highlights – International

- 50-mm dia. YBCO films with $J_c \approx 11$ MA/cm^2 by TFA-MOD (ISTEC).
- 60-m long IBAD/$Gd_2Zr_2O_7$ tape (Fujikura).
  - 9.6-m long tape with end-to-end I_c=50A (J_c=0.4 MA/cm^2).
  - 8-cm long tape with I_c = 150 A (J_c = 1.2 MA/cm^2).
- 10-m long tape (by ISD) with $J_c = 10^5$ A/cm^2 (Sumitomo).
- 5-m long tape (clad-type, metallic substrates) with $J_c > 10^5$ A/cm^2 (Furukawa).
- 2-m long tape (by IBAD) with I_c=142 A (J_c = 1.23 MA/cm^2) (Göttingen).
  - 17.5 m long IBAD tape fabricated .
- 35-m long biaxially textured MgO layer by ISD (tape speed = 8 m/hr) on SS substrate (Munich).
- Korea had established a $146M/10-yr superconductivity initiative.

Summary

- Japan has a large, broad-based, multiorganization effort.
  - Consortia type arrangement
  - Developments are shared among companies; makes it easier for rapid technical progress
  - Achievable targets are set
  - Technical feasibility is most important compared to performance & cost effectiveness
- Impressive IBAD, ISD, and YBCO results are obtained in the European program.
- Small prototype devices using CCs have been demonstrated in Europe and Japan.